PATENT SPECIFICATION

DRAWINGS ATTACHED

838,833

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International Classification: E21b.

Expansible Rotary Drill Bit.

COMPLETE SPECIFICATION

I, ARCHER WILLIAM KAMMERER, of 800 North Raymond Avenue, Fullerton, State of California, United States of America, a citizen of the United States of America, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to rotary drill bits, and more particularly to rotary drill bits of the expansible type adapted to be lowered through well casing to drill or enlarge a well bore below the casing to a greater diameter than the inside diameter of the casing itself.

Rotary drill bits of the expansible type ordinarily include a plurality of cutters disposed initially in retracted position, which are expanded outwardly to enlarge a previously drilled hole. The maximum size of the cutters that can be used is limited by the necessity of disposing them in a retracted position to pass through the well casing or into the previously drilled hole, or both. The size of the cutters places restrictions on the extent that they can enlarge the previously drilled hole, and thereby limits the extent to which they can be expanded outwardly.

Accordingly, it is an object of the present invention to provide a rotary expansible drill bit having cutters that can occupy a retracted position and which can be expanded outwardly to a greater extent than was heretofore possible, to enlarge a previously drilled hole to a substantially greater diameter than heretofore.

Another object of the invention is to provide a rotary expansible drill bit having a plurality of cutters capable of being nested adjacent one another when in retracted position, in which one of the cutters has a greater length than one or more of the other cutters to permit greater outward expansion of all cutters for the purpose of enlarging the well bore to a greater extent, the cutter of greater length operating upon the full annular formation area between the wall of the original hole and the wall of the enlarged hole.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:—

Figure 1 is a longitudinal section, with parts shown in elevation, through an embodiment of the invention with the cutters in retracted position;

Figure 2 is a view similar to Fig. 1 illustrating the cutters in their fully expanded position, taken along the line 2—2 on Fig 3;

Figure 3 is a cross-section taken along the line 3—3 on Fig. 1;

Figure 4 is a view corresponding to Fig. 3 illustrating, somewhat diagrammatically, the cutters after they have been expanded outwardly to their maximum extent;

Figure 5 is a view similar to Fig. 3 illustrating the cutter arrangement on a known design of drill bit;

Figure 6 is a view corresponding to Fig. 4 illustrating the maximum extent of outward expansion of the cutter arrangement disclosed in Fig. 5.

As disclosed in the drawings, a rotary expansible drill bit A is provided which can be secured to the lower end of a string of drill pipe B extending to the top of a well bore, by means of which the drill bit is

lowered through a string of well casing (not shown) to a region below the casing shoe (not shown) where the hole enlarging operation is to commence. The general type of expansible drill bit shown in the drawings is both illustrated and described in Patent No. 766,242 to which attention is invited for certain structural details which are not disclosed nor described herein in detail.

The upper portion of the rotary drill bit consists of a tubular mandrel 10 having an upper pin 11 threadedly connected to the lower end of the string of drill pipe B. This mandrel includes an upper kelly or drill stem member 12 slidably splined to the main body 13 of the bit, as by having a lower non-circular portion 14 of the kelly adapted to be telescopically received in a companion socket 15 formed in the main bit body.

The mandrel 10 has a limited range of longitudinal movement within the body 13, its downward movement being determined by engagement of the lower end 16 of the kelly with an inwardly directed body shoulder 17, its upward movement being limited by engagement of an external shoulder or piston portion 18 of the kelly, which fits within a counterbore 19 in the body of the tool above its socket portion 15, with a cylinder head 20 secured to the body. This cylinder head 20 constitutes the upper portion of a hydraulic cylinder 21 in which the piston 18 operates, the cylinder head having an upper, outwardly directed flange 22 adapted to engage an upwardly facing shoulder 23 in the body to prevent downward movement of the head relative to the body. Upward movement of the head 20 with respect to the body is prevented by one or more split snap retainer rings 24 received within an internal groove 25 in the body and extending across the upper end of the cylinder head.

The upper end of the body 13 is closed by an annular upper guide member 26, including a depending portion 27 received within the upper end of the body and adapted to rest upon or be disposed closely adjacent the retainer rings 24. This upper guide member has an upwardly tapering guide surface 28 in its flange portion 29 which rests on the upper end of the body 13, the guide being removably secured to the body by a split wire snap ring 30, which may be round in cross-section, received within an internal groove 31 in the body and also within an opposed external groove 32 in the guide itself. The ring 30 may completely fill the internal body groove 31, but, when disposed therein, only extends partially into the guide groove 32, such groove being of sufficient lateral depth as to permit the wire ring to be disposed completely therewithin when the guide 26 is inserted into and removed from the upper portion of the bit body 13. When the upper guide 26 is inserted in the body 13, the ring 30 is forced completely within the groove 32 until the ring 30 comes opposite the body groove 31, whereupon it can expand inherently outwardly and be received partly within the groove 31 and partly within the groove 32, thereby releasably assembling the guide member 26 to the body.

The tool body 13 has a plurality of expansible parts mounted on it, including cutter supporting members 36, 36_a pivotally mounted in body slots 37 on hinge pins 38 secured to the body. Each cutter supporting member 36, 36_a depends from a hinge pin 38 and terminates in a bearing supporting pin 60 inclined inwardly and downwardly. A side roller cutter 61 or 61_a is rotatably mounted on each bearing supporting pin. being mounted on anti-friction roller and ball bearing elements 62, 63 rollable on the bearing supporting pin 60. The ball bearing elements 63 lock the cutters against endwise movement on the bearing supporting pin 60, as well as transmitting axial and radial thrusts between each cutter and its associated supporting pin. The roller bearing elements 62 transmit primarily radial thrusts between these parts. The manner of mounting the ball and roller bearing elements 62, 63 between the cutters and bearing supporting pins and of retaining them in place is specifically described in the above-mentioned patent No. 766,242.

The cutter supporting members 36, 36_a and cutters 61, 61_a mounted thereon tend to occupy a retracted position substantially entirely within the confines of the main body 13 of the bit. These cutter supporting members and cutters are expandible outwardly to enlarge the sides of the well bore and to operate upon a formation shoulder C that the cutters produce in the latter. To accomplish the expansion, each cutter supporting member 36, 36_a has an inclined expander surface 64 on its inner portion below the hinge pin 38 which tapers in a downward and inward direction. Each expander surface terminates in a lock surface 65 formed on the cutter supporting member. The outward expansion is accomplished by producing relative longitudinal movement between the mandrel 10 and the bit body 13, which will produce corresponding relative longitudinal movement between the cutter supporting members 36, 36_a and a tubular member 66 of the mandrel. This tubular member includes a lower portion 67 slidable within a guide bushing 68 secured in a guide support 69 attached to the body and extending across the slotted region of the latter below the lock surface 65.

Located initially above the guide 69 and below the hinge pins 38 and in cutter supporting member recesses 70 is a mandrel lock and expander 71 having its outer surface 72 adapted to engage the expander surfaces 64 and the lock surfaces 65. The lock and expander 71 may be formed integrally with the tubular member 66, the upper end of the latter being piloted within a socket 73 in the lower portion of the kelly 12. An enlarged boss 74 on the tubular member engages a downwardly facing shoulder 75 on the kelly, the tubular member being held against the shoulder by a suitable split retainer ring 76 snapped into an internal groove 77 encompassing the kelly socket 73 and engaging a downwardly directed shoulder 78 formed on the tubular member boss. Leakage between the boss 74 and the wall of the kelly socket 73 is prevented by a suitable side seal in the form of a rubber "O" ring 79 disposed within a groove 80 in the kelly 12 and engaging the boss 74.

The kelly 12 has a central fluid passage 81 therethrough communicating with the string of drill pipe B. Fluid pumped through this passage can pass into an aligned central passage 82 in the tubular member 66 and through a central nozzle 83 in its lower portion, whereby drilling mud or similar fluid can be pumped down through the tool for the purpose of removing the cuttings from the well bore and flushing them up around the drill pipe to the top of the hole.

Assuming that the body 13 of the tool is elevated relatively along the tubular mandrel 10, the inclined expander surfaces 64 of the cutter supporting members will be shifted upwardly along the lock and expander portion 71 of the tubular member 66. During such upward shifting, the cutters supporting members 36, 36_a and the cutters 61, 61_a carried thereby will be pivoted about the hinge pins 38 and urged in an outward direction. Movement of the body 13 with respect to the tubular mandrel 10 can continue until the cutters 61, 61_a have been shifted outwardly to their fullest extent, as determined by engagement of stop shoulders 88 on the cutter supporting members 36, 36_a with companion shoulders 89 formed in the body on opposite sides of each body slot 37. When such engagement occurs, the lower end 16 of the kelly portion of the tubular mandrel 10 will engage the body shoulder 17, and the lock and expander 71 on the tubular member 66 will be disposed behind and in engagement with the lock surfaces 65 on the cutter supporting members 36, 36_a.

It is to be noted that the lock surfaces 65 on the cutter supporting members 36, 36_a and the companion surfaces 72 on the lock and expander portion 71 of the tubular member 66 are substantially parallel to the axis of the drill bit, to prevent the reactive forces of the formation on the cutters 61, 61_a from moving the latter inwardly. As a practical matter, it is preferred that the coengaging lock surfaces 65, 72 be inclined slightly in a downward direction toward the axis of the tool to insure release of the lock and expander portion 71 from the cutter supporting member 36, 36_a when the latter and the cutters 61, 61_a are to be shifted back to their retracted position.

The relative longitudinal movement between the tubular mandrel 10 and the body 13 of the tool for effecting outward expansion of the cutters 61, 61_a is accomplished hydraulically. The counterbore 19 receiving the piston 18 of the drill stem member 12 is formed in the upper portion of the body 13 to provide the cylinder 21 having a cylinder wall 90 extending from a lower shoulder 91, defining the bottom of the counterbore, to the location of the upper guide member 26. As was previously described, this upper guide member 26 closes the upper end of the body 13, and can also prevent foreign substances from moving down into the body through the use of a suitable wiper ring 92, which may be in the form of a rubber or rubber-like "O" ring disposed in an internal groove 93 in the upper guide and slidably and sealingly engaging the periphery of the mandrel 10.

The cylinder head 20, which is retained in the upper portion of the body cylinder 21, has an inner seal ring 94, in the form of a rubber or rubber-like "O" ring, received within an internal groove 95 in the cylinder head and slidably and sealingly engaging the periphery of the mandrel 10. This head 20 also has an external seal ring structure in the form of a rubber or rubber-like "O" ring 96 disposed in an external groove 97 in the head and sealingly engaging the wall 90 of the counterbore cylinder 21. The head 20 itself has a depending skirt 98 engaged by the upper end of the piston portion 18 of the mandrel for the purpose of limiting the extent of relative upward movement of the mandrel 10 with respect to the body 13 of the tool. This skirt 98 is disposed at the outer portion of the cylinder head 20 to provide an annular space 99 between the periphery of the mandrel or kelly 12 above the piston portion 18 and the skirt itself into which fluid under pressure from the central passage 81 of the mandrel can enter, such fluid flowing through intercommunicating lateral ports 100 in the mandrel immediately above the piston portion 18.

Fluid from the cylinder space 99 is prevented from passing downwardly around

the periphery of the piston 18 by a suitable side seal ring 101, such as a rubber or rubber-like "O" ring, disposed in a piston groove 102 and sealingly engaging the cylinder wall 90.

Fluid under pressure in the string of drill pipe B and within the tubular mandrel 10 is fed into the cylinder space 99 through the side ports 100, such fluid under pressure being developed by the back pressure built up through the necessity of the fluid to pass through the relatively restricted passage 82 through the tubular member 66 and the nozzle 83 at its lower portion. This back pressure imposed on the fluid in the cylinder space 99 acts in an upward direction on the cylinder head 20, urging the body 13 of the tool upwardly with respect to the tubular mandrel 10 and correspondingly elevating the cutter supporting members 36, 36_a and cutters 61, 61_a with respect to the lock and expander portion 71 of the tubular member 66, until the cutters 61, 61_a are expanded to their fullest extent. Thus, with the fluid pressure elevating the body relative to the mandrel, the tool can be rotated, the cutters 61, 61_a operating upon the formation and gradually being expanded outwardly as the body continues to be elevated along the mandrel until the cutters have been expanded outwardly to their fullest extent, as determined by engagement of the cutter supporting arm shoulders 88 with the companion body shoulders 89. When this occurs, the mandrel and lock portion 71 is disposed behind companion lock surfaces 65 of the cutter supporting members 36, 36_a to retain the cutters 61, 61_a in their outwardly expanded position, the downward drilling weight being transmitted from the lower end 16 of the kelly 12 to the body shoulder 17, and from the stop shoulders 89 on the latter on opposite sides of the slots 37 to the cutter supporing members 36, 36_a being transmitted from the latter through the cutters 61, 61_a to the formation shoulder C. The cutters 61, 61_a will remain locked in their outwardly expanded position so long as drilling weight is being imposed upon the drill pipe B and the drill bit A, the cutters 61, 61_a operating upon the formation shoulder C to progressively enlarge the bore in a downward direction. During the drilling operation, a guide D of any suitable form, which is mounted on the lower portion of the body 13, centers the drill bit in the original hole E. When expanded, the cutters 61, 61_a will produce the enlarged hole F.

With the cutters 61, 61_a in their outwardly expanded position, as disclosed in Fig. 2, down weight is imposed thereon and the drill bit rotated through the drill pipe, the cutters operating upon the formation shoulder C and enlarging the hole in the downward direction. After the desired length of hole has been enlarged, or the cutters have become worn, the tool may be retrieved from the well bore by discontinuing the pumping of fluid therethrough and elevating the drill pipe B and the mandrel 10 attached thereto. Such action will elevate the lock portion 71 of the tubular member 66 above the lock surfaces 65 on the cutter supporting members 36, 36_a, allowing the latter and the cutters 61, 61_a carried thereby to move back to their retracted position, such as disclosed in Fig. 1. The tool may now be elevated in the well bore and moved back through the well casing to the top of the hole.

In the type of tool illustrated in the drawings, the bearing supporting pins 60 are disposed the same distance below the hinge pins 38 and all of the cutter supporting members 36, 36_a and cutters 61, 61_a are expanded outwardly to the same extent, to drill the enlarged hole F. Heretofore, the cutters 61, 61_a have all been made alike, having the same cutter length and the same diameter. With the same length of cutter supporting member 36, 36_a and the same size cutter, the cutters would each have a certain maximum length, as dictated by the need for the cutters to be disposed in their fully retracted position substantially completely within the confines of the body 13, and by the fact that the cutters could only be located inwardly of the body to the point at which they did not interfere with one another. Such arrangement of cutters 61x is illustrated in Fig. 5, the outer portions of the cutters being disclosed in relation to the diameter of the previously drilled hole E which is to be enlarged.

With the cutter arrangement illustrated in Fig. 5, they can be expanded outwardly, as a practical matter, to increase the radius of the hole by an amount which corresponds to the length L of each cutter. That is to say, that length of the formation shoulder that is produced in the well bore could be no greater than the length L of the cutter teeth, the cutter teeth extending from the inner wall of the drilled hole E to the inner wall of the enlarged hole F1. This condition is illustrated diagrammatically in Fig. 6. If the cutters 61x were expanded outwardly beyond the extent indicated, then the inner ends of the cutter teeth would be disposed outwardly of the inner wall of the hole E, and would not operate across the full face of the formation shoulder C, which would impede progress of the bit through failure to drill the hole, or which would result in the failure of the bit to make any progress at all.

By virtue of the present invention, the

cutters 61, 61_a and the cutter supporting members 36, 36_a can initially occupy a retracted position substantially completely within the confines of the body 13 of the drill bit and can be expanded outwardly to a greater extent, in order to increase the size of the initial hole E to a much greater diameter than heretofore, assurance being had that the drill bit cutters will operate upon the full face of the shoulder C produced between the inner wall of the original hole E and the inner wall of the enlarged hole F, such as disclosed in Figs. 2 and 4.

In accomplishing the purpose of the present invention, one of the cutters 61_a is made longer than the other cutters 61. That is to say, the other cutters 61 are shorter in length L^1 than the corresponding cutters 61x represented in Fig. 5, whereas the one cutter 61a is made longer in length L^2 than the corresponding cutter represented in Fig. 5, this latter cutter 61a extending inwardly to a further extent than the corresponding cutter represented in Fig. 5. The outer portions of all of the cutters could be substantially the same, as illustrated in Fig. 2, such outer portions lying within the confines of the body 13 when in retracted position. The cutters 61, 61^1 arranged and proportioned as disclosed in Figs. 1 to 4, inclusive, can be expanded outwardly to a greater extent than the cutter arrangement and proportions illustrated in Figs. 5 and 6, to enlarge the size of the bore hole E to a greater extent. As shown in Figs. 2 and 4, the cutter supporting members 36, 36_a and the cutters 61, 61_a have been expanded outwardly to a greater extent than shown in Fig. 6 to drill a hole F having a radius that is greater than the hole size F^1 by the amount indicated by the letter G in Fig. 6. In that figure, the circle F represents the size of the enlarged hole drilled by the cutter arrangement illustrated in Fig. 1 to 4 inclusive, whereas the letter F^1 indicates the size of the enlarged hole that can be produced by the cutter arrangement and proportions shown in Fig. 5. The enlarged hole F will be produced with the cutter 61_a operating upon the entire radial extent of the shoulder C, extending from the wall of the original hole E to the wall of the enlarged hole F. Such increase in expansion of the cutters to drill the increased hole size F is made possible by the fact that the length of the cutter 61a is greater than heretofore, so as to be capable of operating upon a shoulder C that is substantially greater than was heretofore possible. The greater size hole will be produced despite the fact that the length of the cutters 61 has been decreased. As shown in Figs. 2 and 4, the cutters 61 do not operate upon the inner annular portion H of the formation shoulder C. Despite this fact, the inner annular portion H of the shoulder C is still being operated upon by the inner portion of the teeth of the cutters 61a, as is clearly evident from Figs. 2 and 4. The cutters 61 cooperate with the cutters 61a in performing by far the greater proportion of the drilling action to enlarge the well bore from the size of the hole E to the size of the hole F. The amount of material that must be removed by the inner portion of the cutter 61a alone, represented by the annulus H in Fig. 2, is relatively small, and such removal occurs without difficulty.

It is, accordingly, apparent that a rotary drill bit has been provided in which the cutters can be expanded outwardly to a great extent to correspondingly enlarge the size of a preexisting well bore E to a greater extent, such as to the size of the well bore F, with assurance that all portions of the formation shoulder C lying between the inner wall of the original hole E and the inner wall of the enlarged hole F will be acted upon by at least one cutter of the apparatus. A substantial increase in the size of the enlarged hole is thereby made possible, the increase in the size of the enlarged hole being represented diagrammatically and by way of example by the letter G in Fig. 6.

WHAT I CLAIM IS:—

1. A rotary drill bit for well bores comprising a body; first cutter means mounted on said body for lateral movement with respect to said body; second cutter means mounted on said body for lateral movement with respect to said body; both of said cutter means being adapted to occupy a fully retracted position on said body closely adjacent one another with said first cutter means extending inwardly of said body to a substantially greater extent than said second cutter means; and means engaging both of said cutter means and movable with respect to said body for expanding both of said cutter means outwardly of said body to the extent at which the inner cutting portion of said first cutter means extends substantially closer to the axis of the body than the inner cutting portion of said second cutter means.

2. Rotary drill bit according to claim 1, characterized in that each of the first and second cutter means comprise a supporting member and a roller cutter rotatably mounted on said supporting means.

3. Rotary drill bit according to claim 2, characterized in that the outer portions of both of said cutters are substantially equidistant from the axis of the body.

4. Rotary drill bit according to claims 2 and 3, characterized in that the first cutter has greater cutter length than the second cutter.

5. Rotary drill bit according to claims 1 to 4 characterized in that means are provided for expanding the said supporting members and cutters outwardly of said body to the same extent whereby the outer portions of said cutters are substantially equidistant from the body axis and the inner cutting portion of the first cutter extends substantially closer to the axis of the body than the inner cutting portion of the second cutter.

6. Rotary drill bit according to any of the preceding claims characterized in that said cutters are rotatable on their respective supporting members about axes making a substantial angle to the body axis.

7. Rotary drill bit according to claim 5 characterized in that said cutters are operable upon a transverse formation shoulder in the well bore.

8. Rotary drill bit according to any of the preceding claims characterized in that both of said cutters have cutter teeth extending laterally of the axis of the body.

9. Rotary drill bit for well bores, comprising a body; three supporting members mounted on said body for lateral movement with respect to said body; a first roller cutter rotatably mounted on one of said supporting members; a roller cutter rotatably mounted on each of said other supporting members; said supporting members and cutters being adapted to occupy a fully retracted position on said body with said first cutter closely adjacent said other cutters and the other portions of all of said roller cutters substantially equidistant from the axis of the body, said first roller cutter having a greater cutter length than both of said other cutters so as to extend inwardly of said body, when in retracted position thereon, to a substantially greater extent than said other roller cutters; and means engaging said supporting members and movable with respect to said body for expanding all of said supporting members and cutters outwardly of said body to the same extent, whereby the outer portions of all of said cutters are substantially equidistant from the body axis and the inner cutting portion of said first roller cutter extending substantially closer to the axis of the body than the inner cutting portions of said other roller cutters.

10. A rotary drill bit for well bores substantially as hereinbefore described and is illustrated in the accompanying drawings.

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FIG. 1.

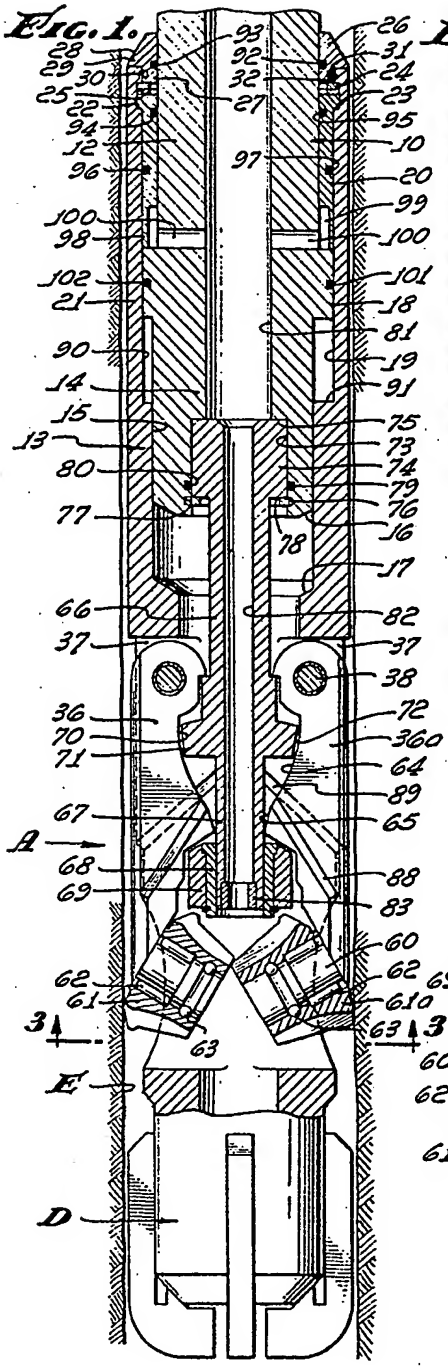
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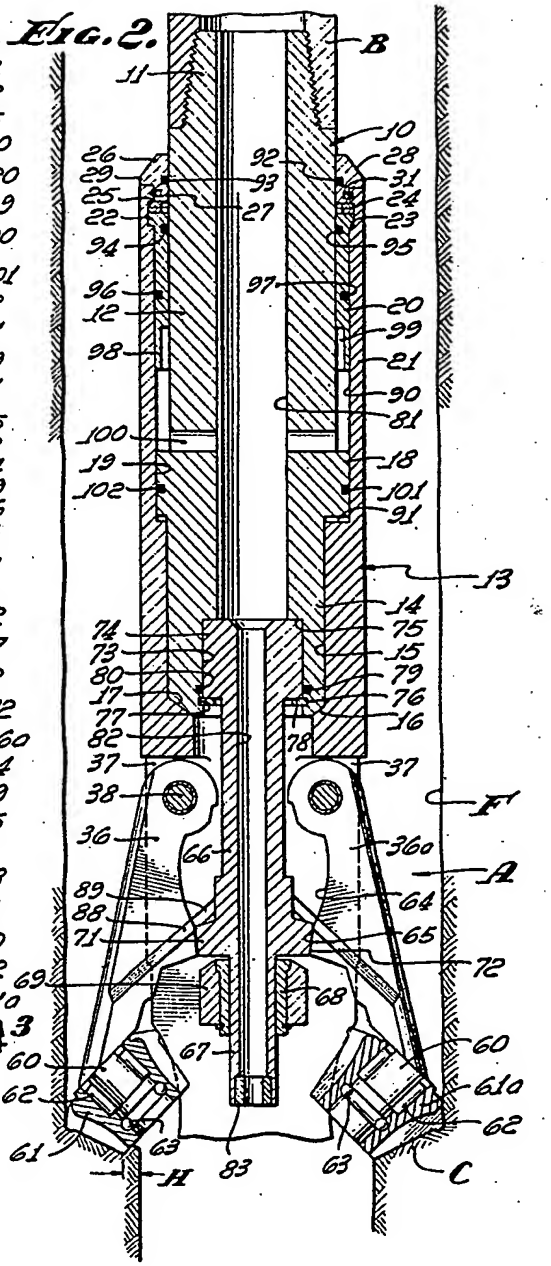
FIG. 2.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838,833 COMPLETE SPECIFICATION
2 SHEETS

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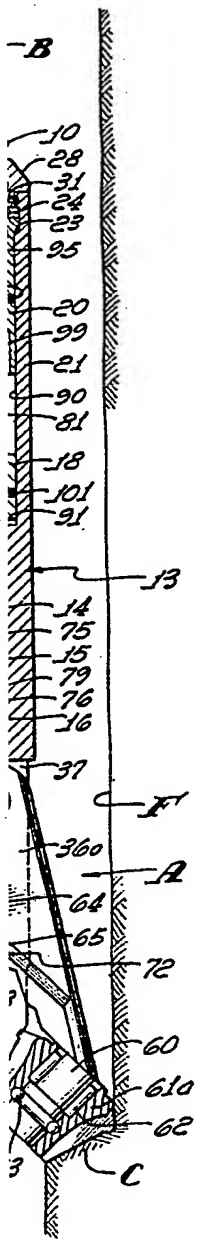


Fig. 3.

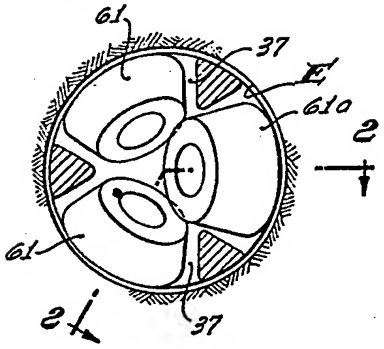


Fig. 4.

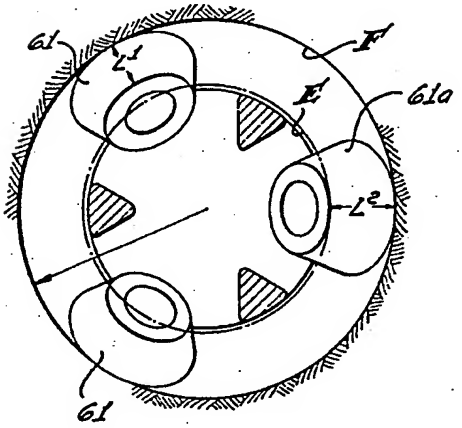


Fig. 5.

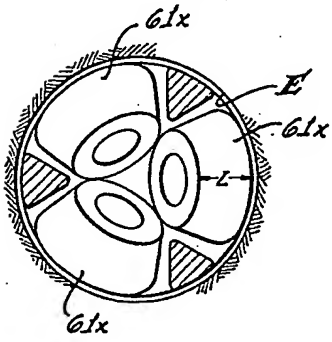
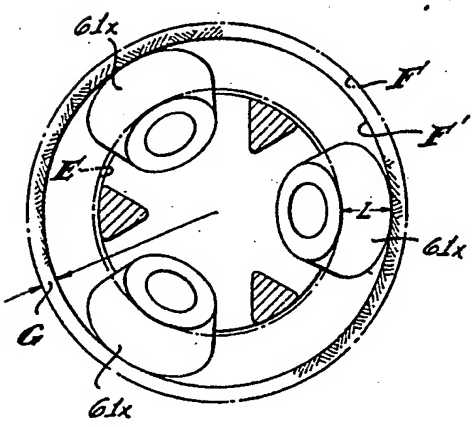


Fig. 6.



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SHEETS 1 & 2

Fig. 1.

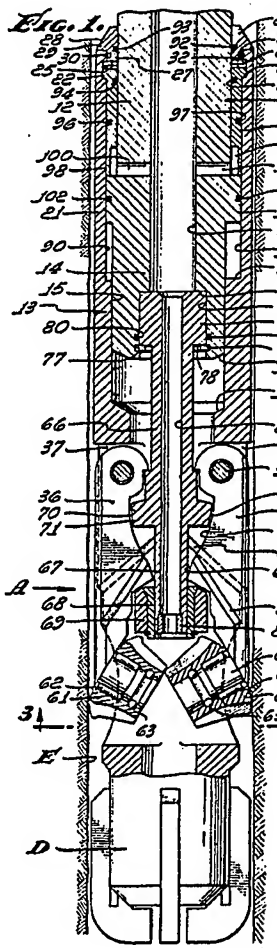

Fig. 2.

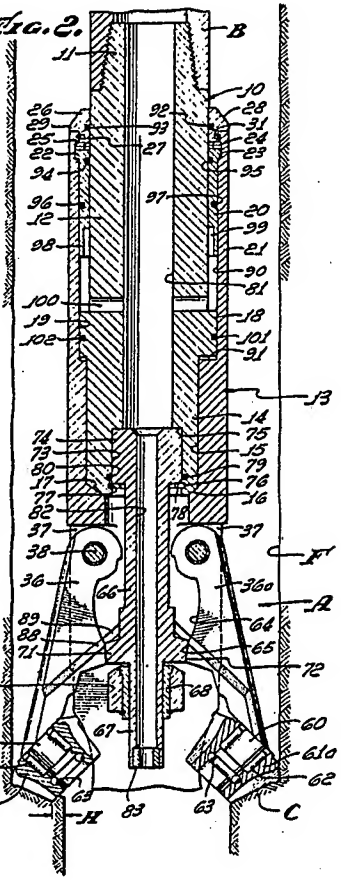

Fig. 3.

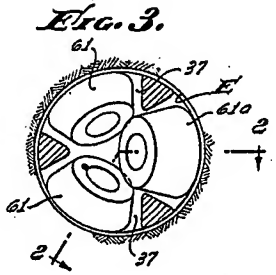

Fig. 4.

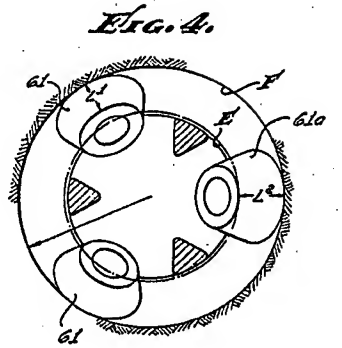

Fig. 5.

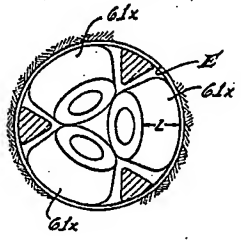

Fig. 6.